

Energy-transfer upconversion in $\text{Al}_2\text{O}_3:\text{Er}^{3+}$ thin layers

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Erbium-doped aluminum oxide ($\text{Al}_2\text{O}_3:\text{Er}$) is a promising material for integrated amplifier or tunable laser applications due to its wide gain spectrum around 1550 nm. We deposited Al_2O_3 layers on thermally oxidized Si-wafers by reactive co-sputtering at 550°C [1]. Propagation losses were 0.11 dB/cm at $\lambda = 1.5 \mu\text{m}$. Channel waveguides were fabricated by reactive ion etching with propagation losses down to 0.21 dB/cm [2]. Under pumping at 977 nm, the optical small-signal gain at 1533 nm is 0.84 dB/cm, resulting in 5.4 dB net gain over the waveguide length of 6.4 cm [1]. Net gain is obtained over a wavelength range of 41 nm (Fig. 1).

The Er concentration was measured using Rutherford Back-Scattering (RBS). Lifetimes of the $^4\text{I}_{13/2}$ level of up to 7 ms were measured for Er concentrations around $2 \times 10^{20} \text{ cm}^{-3}$. A faster decay with an increasingly non-exponential initial component is measured for higher Er concentrations (Fig. 2). While the initial quenching is probably due to migration-accelerated energy-transfer upconversion between neighboring Er^{3+} ions in the $^4\text{I}_{13/2}$ level, the decreasing exponential tail is due to either pair-induced energy-transfer upconversion or quenching by impurity ions. Detailed investigations of the quenching mechanisms are currently under way.

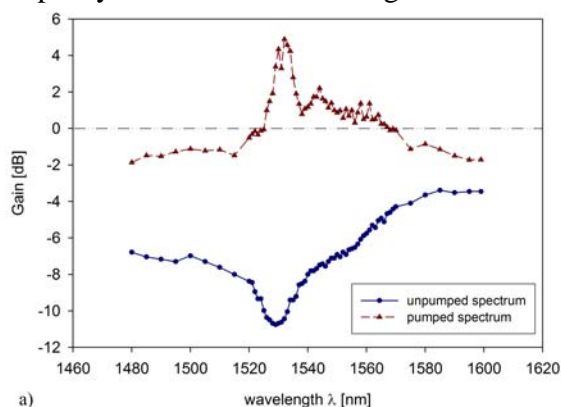


Fig. 1. Net gain in a sample with Er concentration 0.09at% ($0.8 \times 10^{20} \text{ cm}^{-3}$) as a function of wavelength

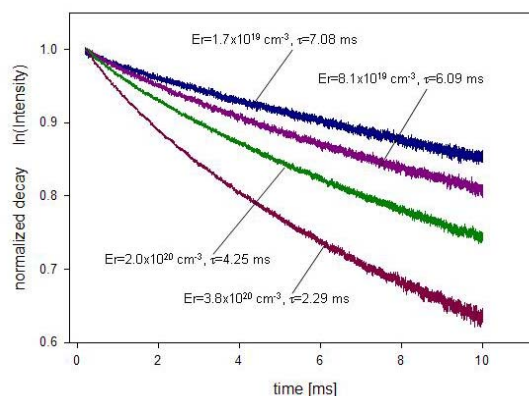


Fig. 2. Luminescence decay curves at $1.5 \mu\text{m}$ for different Er concentrations

References

- [1] K. Wörhoff, J.D.B. Bradley, F. Ay, D. Geskus, T.P. Blauwendraat, M. Pollnau, "Reliable low-cost fabrication of low-loss $\text{Al}_2\text{O}_3:\text{Er}^{3+}$ waveguides with 5.4-dB optical gain", IEEE J. Quantum Electron., submitted (2008).
- [2] J.D.B. Bradley, F. Ay, K. Wörhoff, M. Pollnau, "Fabrication of low-loss channel waveguides in Al_2O_3 and Y_2O_3 layers by inductively coupled plasma reactive ion etching", Appl. Phys. B **89**, 311-318 (2007).